Asia Pacific Journal of Engineering Science and Technology

https://www.researchgate.net/publication/271587685

Nano-materials

Self-Lubricating Alumina

Pranti Tawheed[1], Faisal Bin Shahin[1], Md. Khizir Al Zabir[1], A K Ehsanul Haque Mashuk[1], Mehdi Alam[1], Md. Nasfikur R. Khan[2,*]

[1]*Student, Department of Electrical and Electronic Engineering, Independent University, Bangladesh*
[2]*Lecturer, Department of Electrical and Electronic Engineering, Independent University, Bangladesh*

(Received 6 November 2017; accepted 13 December 2017; published online 23 December 2017)

ABSTRACT

Aluminium Oxide (Al_2O_3) is a self-lubricating based on nanocomposites. This are mostly used material in engineering sector for its high-tech structural application, stiffness, light weight, strength, elasticity and durability. Based on expert's research, Aluminium Oxide nanocomposites are a combination of Al_2O_3 and a metal matrix element (Metal, Polymer or Ceramic). Self-lubricating Aluminium Oxide are widely used in many industrial applications such as laminates, adhesives and construction materials, aircraft, racing boats, aerospace and automotive applications. Technology of friction, wear and lubrication of relative motion surface is known as Tribology. In that essay/report we will try to research on technical aspects of tribological properties of self-lubricating Al_2O_3-based nanocomposites along with its micro structural preparation and mechanical properties.

Keywords: Alumina; Self-lubricating; Tribology

1. Introduction

A nanocomposite consists of both artificial or man-made material. It is a matrix to which nanoparticles have been added to improve a property of the material. Mainly designed for increasing performance in different application like structural, functional or cosmetic. This material can be of different kind like plastic, or ceramic or a combination of different nanoparticles for example Zirconia, Alumina etc.

*E-mail address: mnrkhan@iub.edu.bd

Impacts of nanocomposites

- Nanocomposites are used for Electron micrograph (Silicon nanocomposite)
- Nanocomposites are also used for improving vehicle's mileage
- Nanocomposites are used in aero planes for light weight quality.

1.1 Brief discussion on alumina

Aluminium Oxide or Alumina is a kind of nanocomposite, which is a chemical compound comprised of aluminum and oxygen molecules (Al_2O_3). Alumina is also known as Aloxide, Aloxite or Alundum based on the formation or applications. In case of ornament Alumina is also known as Ruby or Sapphire. Alumina is one of the important materials in structural ceramic application because of its excellent mechanical properties, good chemical stability and high temperature characteristics. Self-lubrication alumina has the ability of bearing capability to delivery microscopic amounts of material to the malting surface. Al_2O_3-based nanocomposites were stated by using X-Ray Diffraction technique which helps to find the size of average crystalline. Scanning Electron Microscopy is needed for finding the characteristics of morphology of Alumina based nanocomposites.

2. Preparation

Based on different components (Ni, Al, Cr, Cu etc.), possible ways of fabrication are different like, electroless plating method, heat (hot) pressing method, vacuum coating method etc. Here, we try to discuss the manufacturing process for forming microstructure of Al_2O_3 or Alumina ceramics. This process consists of following steps: -

2.1 Powder Preparation

In general size of the Al_2O_3 powder is not more than 2.0 micro meters. In recent years by electroless copper plating copper-coated Al_2O_3 powders are prepared. The copper plating solution is consisting of copper surface solution 35-50 g/l CuSO4.5H2O, 18-36 ml/l formaldehyde, 66 g/l EDTA and 12 g/l NaOH. During the removal of copper, the pH value of the plating solution continuously being controlled. Here, NaOH plays role in settling the plating bath of pH value. In total of 20 minutes used for plating time, pH is kept at 12 and a deposition temperature of 30±2ºC during the electro less plating. To clean the powder distinct water is used and drying in incubator at 60 degrees Celsius.

3. Compacting or forming shape

In this procedure the value of applied pressure and hot pressing are considered. For sintering and pressing a fine alumina powder 1600 degree Celsius temperature should be maintained. Porous size and residual internal stresses resolved the amount of binders and other supplement like plasticizers, lubricants, deflocculates etc.

4. Sintering

During sintering process, diffusion is proceeding for the reason of the pores is decreasing, which results densification of the Al_2O_3 or alumina ceramic material. In the main phase of ceramic, the bonding and other phases are shared in between them. There is a chance of matrix grains to increase during the sintering process. To limit the growth of grain Magnesium Oxide, MgO (<0.5%) has been added to it. Through the sintering process final alumina grains and pore sizes has been determined along with physical and chemical uniformity. Overall time duration was around 15 minutes and applied pressure is 30MPa.

5. Micro-structure

Microstructure which is clearly visible and can be properly examined with a microscope. The surface morphology of the core shell structured copper coated Al_2O_3, which are characterized by SEM (scanning electron microscopy) established with energy dispersive spectroscopy or EDS. Microstructure of the Al_2O_3-Si nanocomposites and Al_2O_3-Ni nanocomposites are not the same. As the grain growth of alumina's is very high nanocomposite like SiC (Silicon Carbon) or MgO (Magnesium Oxide) uses as a matrix metal with self-lubricating alumina (Al_2O_3) to reduce the rate of growth.

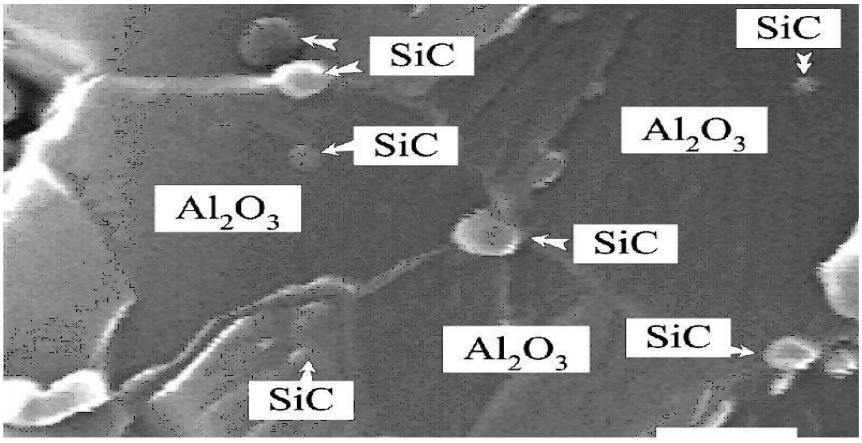

Fig. 1 sample of self-lubricating alumina microstructure through a microscope

6. Properties

In that part, we will discuss the mechanical properties of Alumina (Al2O3) nanocomposites.

Table 1 Mechanical Properties

Properties	Value
Hardness	82 Rockwell 45N
Elasticity	46 psi X 10^6
Tensile Strength	54 kpsi
Compression	368 kpsi
Toughness	4.3 MPa m^ (1/2)
Flexation	51 kpsi
Poission's Ratio	0.20<Al2O3<0.25

Self-lubricating alumina has various amount of properties like specified hardness, superior wear resistance, tensile strength etc. Normally, Alumina is a hard nanocomposite, because of the metal matrix components like Ni, Cr, Co, Ti (which are the strongest material of earth) self-lubricating alumina is one of the hardest nanocomposite. Besides, inclusion of Al2O3 also increase strength on those metal matrices. Tensile strength of self-lubricating alumina is the resistance of that material for breaking under specific pressure and temperature. Tensile strength of self-lubricating alumina is stronger to take load or pressure than most of the self-lubricating nanocomposites or any other nanocomposites.

High purity self-lubricating alumina is an ideal nanocomposite for environments where resistance to wear and corrosive substances are required. Self-lubricating alumina nanocomposite has excellent thermal stability and that means, it is widely used in areas where high temperatures resistance is necessary.

6. Tribological properties of self-lubricating alumina

According to our previous discussions, friction, wear and lubrication technology of relative motion surface is known as Tribology [7]. Based on some research, it has been found that the density of self-lubricating alumina is the main reason for its friction property. Besides, we already discuss the wear resistance of that nanocomposites. Lubrication properties of alumina nanocomposites are based on the coating technology and there are two different kinds of coating techniques used for alumina, analogue and direct current installation methods [8-11]. These techniques increase the nano-sized element and combination of similar kinds of particles distribution effect alumna's tribological behaviour. Besides, size of some grain matrixes like Ni

or Cr also increase wear resistance possibility, which also effect the lubrication of the nanocomposites (alumina, Al_2O_3).

7. Conclusion

Among different kinds of nanocomposites, alumina or Al2O3-based nanocomposites are the most ideal materials for any engineering prospects. In that report we try to discuss a scientific procedure for manufacturing alumina based nanocomposites. Alongside, it has been discussed some technical aspects like mechanical and tribological properties of alumina based nanocomposites [12]. Although, alumina based nanocomposites are among the most effective nanocomposites are found, still scientists are trying to improve its properties to accomplish more applications.

References

[1] ASudheer Kumar, V. Rao, Chakraverti, S. Chakra, Tribological Properties Of Epoxy/Al2o3 Nanocomposites, Vol: 4, Issue: 5, [May, 2013]

[2] Takahashi Koji, Ando Kotoji and Nakao Wataru, Yokohama National University [1996].

[3] Aleksandar Marinkovic, ISLPRCTP, University of Belgrade [13-15 May, 2009].

[4] Ostroumov S. A. STFOPITE: BINDING ANDIMMOBILIZATION OF NANOPARTICLES AND CHEMICAL ELEMENTS. - Ecologica, 2011, vol. 18, No. 62, pp. 129-132; Scientific Paper: article language: English

[5] Gui, H.; Aslan, S., HCENGCURCE, Surface & Coatings Technology, 2006, Vol: 200(11), PP. 3633-3636.

[6] Md. Nasfikur R. Khan, Mohammad N. H. Pias, K. Habib, M. Hossain, F. Sarker and K. A. Mamun, "Bolte Chai: An Augmentative and Alternative Communication Device for Enhancing Communication for Nonverbal Children", International Conference on Medical Engineering, Health Informatics and Technology (MediTec), Dhaka on 17 -18 December, 2016. ISBN: 978-1-5090-5421-3. http://ieeexplore.ieee.org/document/7835391/

[7] Md. Nasfikur R. Khan, Md. Rakib Hasan, "Designing A Home Automation System By Using RF Receiver", International Journal of Advance Research and Innovative Ideas in Education, Vol 3 (4), June, 2017. pp. 2318 - 2322. http://ijariie.com/FormDetails.aspx?MenuScriptId=35160

[8] Md. Faijul Haque, Sabrina Hossain, Ayesha Siddika and Md. Nasfikur R. Khan, "Smart Home Automation System based on Environmental Monitoring System," National Conference on Electronics and ICT, Dhaka, 2017, pp. 1-4.

[9] Md. Nasfikur R. Khan, Sarmila Yesmin, "Improving controlling system of a finger simulator", Asian Journal of Engineering and Technology, Vol 5 (4), August, 2017. pp. 113-118. http://www.ajouronline.com/index.php/AJET/article/view/4946.

[10] Md. Nasfikur R. Khan, Faisal B. Sahin, Md. Asif Rahman, Pranti Tawheed, Sarmila Yesmin, "In Vitro: Improving controlling system of a finger simulator", Asia Pacific Journal of Engineering Science and Technology, Vol. 3 (3), August, 2017. pp. 100 - 106. http://apjest.com/img/APJESTD173301.pdf

[11] Md Ziaul Islam, Mehedi Hasan and Md. N. R. Khan, "Power Generation Engine Biomass Resources, according to meet the feature demand- Bangladesh perspective", The Journal of City University, March 2016, Volume: 01, Issue: 02, Page: 29.

[12] Md. Nasfikur R. Khan, Md Ziaul Islam and Md Mehedi Hasan, "Cos-effective and User Friendly Customized Prosthetic Hands for Children - Design and Human Integration", The Journal of City University, March 2016, Volume: 01, Issue: 02, Page: 63.